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RESEARCH MEMORANDUM

JET EFFECTS ON PRESSURE LOADING OF ALL-MOVABLE HORIZONTAL STABILIZER

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS
WASHINGTON
June 10, 1954

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

RESEARCH MEMORANDUM

JET EFFECTS ON PRESSURE LOADING OF ALL-MOVABLE HORIZONTAL STABILIZER

By Alfred S. Valerino

SUMMARY

An investigation was conducted in the NACA Lewis 8- by 6-foot supersonic tunnel to determine the effects of a cold exhaust jet on the pressure loadings of an all-movable, 45° sweptback horizontal stabilizer located in a region influenced by the jet. The investigation also included the effects of the stabilizer on the drags of the boattail, base annulus, and secondary-flow passage of a jet-exit model operating at Mach numbers of 0.63, 1.5, and 1.8 and at zero angle of attack. The test was conducted through a range of jet pressure ratios from 1 to 9 at stabilizer deflection angles of 0°, 5°, and 10°.

Results of this investigation indicate that at jet pressure ratios of 1 to 9 the exhaust jet did not appreciably affect the pressure loadings of the stabilizer. The largest jet effects on the stabilizer were confined to a small region near the nozzle shroud and trailing edge of the stabilizer.

The presence of the stabilizer resulted in large increases in the drags of the base and secondary-flow passage.

INTRODUCTION

An investigation was conducted in the NACA Lewis 8- by 6-foot supersonic tunnel to determine the effects of a cold exhaust jet on the pressure loadings of an all-movable horizontal stabilizer located in the vicinity of the jet. The investigation was conducted at free-stream Mach numbers of 0.63, 1.5, and 1.8 through a jet pressure-ratio range of 1 to 9 with 3-percent secondary flow at stabilizer deflection angles of 0°, 5°, and 10°.

In addition, instrumentation was included on the jet-exit model to determine the effects of the stabilizer on boattail and base pressures.

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SYMBOLS

The following symbols are used in this report:

A	aspect ratio, b^2/S, 3.5
b	span of horizontal stabilizers, 2.695 ft 3261
$C_{p,a}$	base annulus pressure coefficient, $(p_a-p_0)/q_0$
$C_{p,B}$	base bleed pressure coefficient, $(p_B-p_0)/q_0$
$C_{p,b}$	boattail pressure coefficient, $(p_b-p_0)/q_0$
$C_{p,s}$	stabilizer pressure coefficient, $(p_s-p_0)/q_0$
M	Mach number
P	total pressure
P_1/p_0	jet pressure ratio
p	static pressure
q	dynamic pressure
S	area of horizontal stabilizers, 2.076 sq ft
x	distance upstream of base
δ	stabilizer deflection angle

Subscripts:

a	base annulus of afterbody
B	bleed passage
b	boattail
s	stabilizer
0	free stream
1	conditions upstream of nozzle exit

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APPARATUS AND PROCEDURE

A schematic diagram of the wind-tunnel installation of the jet-exit model is presented in figure 1. The model was supported by two hollow struts of circular cross section that were attached to trunnions mounted in the tunnel wall. The model air flow, which was obtained from a source outside the tunnel, was measured with a sharp-edge orifice before it passed through the hollow support struts into the model. The model internal pressure was regulated by means of a butterfly valve located downstream of the orifice.

The horizontal stabilizers, which had a dihedral angle of 5°25', were rotated 90° so that they would not be located in the wakes from the horizontal support struts (fig. 1). A photograph of the stabilizers attached to the afterbody is shown in figure 2. The stabilizers had an aspect ratio of 3.5, a taper ratio of 0.15, a sweepback of 45° at the quarter-chord line, and an NACA 65A006 airfoil section parallel to the free stream at the stabilizer root section. However, the thickness of the stabilizer was tapered to 4 percent at the tip section. The plan-form dimensions of the tail surface are presented in figure 3, along with a table listing the location of the 44 static orifices (22 orifices on the pressure and 22 on the suction surfaces of one stabilizer) used to determine pressure loadings. The pressure and suction surfaces of the stabilizers correspond to the upper and lower surfaces, respectively, of a stabilizer positioned in the horizontal plane.

The stabilizers were investigated at deflection angles of 0°, 5°, and 10° and in two longitudinal positions with respect to the nozzle exit, as shown in figure 4. With the stabilizers in the aft position, the trailing edge of the root section was positioned 1.634 inches downstream of the nozzle exit; in the fore position, 0.085 inch upstream of the nozzle exit.

The model afterbody pressure instrumentation is presented in figure 5. Ten wall statics were used to measure boattail pressures. Base pressures were measured with four static orifices on the base annulus of the afterbody. Internal instrumentation consisted of a 10-tube total-pressure rake located in the constant-area section upstream of the convergent nozzle and used to determine model internal pressures. Six static orifices on the outer surface of the nozzle were used to determine pressures in the secondary-flow passage. Thirty holes of 0.136-inch diameter were drilled circumferentially around the nozzle at station 70.63 to provide for secondary flow. A calibration of the bleed holes was used to determine the secondary weight-flow ratio.

RESULTS AND DISCUSSION

The discussion herein pertains only to the results obtained from configurations with 3-percent secondary-flow ratio at free-stream Mach number of 1.5, inasmuch as similar results were obtained at Mach numbers 0.63 and 1.8. The chordwise pressure coefficients of the stabilizer at Mach numbers of 0.63 and 1.8 for the range of jet pressure ratios investigated are presented in table I.

The chordwise pressure distributions of the stabilizers at the jet-off condition and at the jet pressure ratio P_1/p_0 of 9 are presented in figure 6. Since the tubing of the static orifices at chord stations 4.65 and 14.8 of tail station 4.50 leaked, only the jet-off data points are plotted at tail station 4.50. The distributions at jet pressure ratios of 1, 4, and 6 exhibit the same trends as do those at pressure ratio of 9 and were, therefore, not included in the figures. The data presented in figure 6 indicate that the influence of the jet on the pressure loading of the stabilizers is not appreciable. At stabilizer deflection angle of 0° (fig. 6(a)), the jet effect was felt spanwise to tail station 4.50. Increasing the deflection angle resulted in a spanwise spreading of the jet effect; with the stabilizer deflected 5° (fig. 6(b)), the pressures to tail station 5.50 were influenced; while at 10° deflection angle (fig. 6(c)), the jet affected the distribution of the stabilizer to tail station 7.09 (suction side only at tail station 7.09). For each of these configurations, however, the jet effects were confined within the region bounded by the 65- and 100-percent-chord stations. 3261

Moving the stabilizer to the fore position (fig. 6(d)) reduced the jet effects. With a deflection angle of 10°, the jet effect was limited spanwise to tail station 4.50 and chordwise between the 70- and 100-percent-chord stations, on the suction side of the stabilizer only.

The effect of the stabilizer on the boattail pressure distribution is presented in figure 7. For zero deflection angle, the boattail pressures on both sides of the stabilizer were nearly equal. As would be expected, increasing the deflection angle resulted in a decrease in pressure near the suction side and an increase near the pressure side of the stabilizer. At pressure ratios of 6 and 9, flow separation on the boattail was experienced with the configurations with the body alone and with the stabilizer deflected 0°. As the deflection angle was increased, only the flow passing by the suction side of the stabilizer was separated.

The effect of the stabilizer on the base annulus pressure coefficients is presented in figure 8. The annulus pressure coefficients obtained from the configurations with stabilizers were not appreciably affected by the stabilizer deflection angle or by the stabilizer position. However, the presence of the stabilizer resulted in large increases in base annulus pressure coefficients. At jet pressure ratios of 4 and 9, the base pressure coefficients of the configurations with stabilizers were, respectively, approximately 37 and 150 percent higher than those of the body-alone configuration.

Pressure coefficients in the secondary-flow passage (fig. 8) were affected in a manner similar to the base annulus coefficients. Up to pressure ratios of 6, the pressures of the configurations with stabilizer did not vary significantly. However, as the pressure ratio was increased to 9, the drags due to the secondary flow, for the configurations with the stabilizer deflected 0° and 5°, were considerably higher than those of the configurations having the stabilizer deflected 10°. At jet pressure ratio of 4, the bleed-passage drag of the configurations with stabilizers was approximately 29 percent higher than that of the body-alone configuration. At pressure ratio of 9, the drags due to secondary flow for the configurations with stabilizers deflected 0° and 5° and the configurations with stabilizers having a deflection angle of 10° were, respectively, approximately 90 and 35 percent higher than the drag of the body-alone configuration.

SUMMARY OF RESULTS

An investigation was conducted to determine exhaust-jet effects on the pressure loading of an all-movable, 45° sweptback horizontal stabilizer located in a region influenced by the jet. The stabilizer effects on the boattail, base annulus, and secondary-flow-passage drags of the jet-exit model were also investigated at zero model angle of attack through a range of jet pressure ratios from 1 to 9 with 3-percent secondary-flow ratio, and at stabilizer deflection angles of 0°, 5°, and 10°. The following results were obtained at free-stream Mach numbers of 0.63, 1.5, and 1.8:

1. Pressure loadings on the stabilizer were not appreciably affected by the jet pressure ratio.

2. The addition of the stabilizer to the basic configuration resulted in large increases in base annulus and secondary-flow-passage drags.

Lewis Flight Propulsion Laboratory
National Advisory Committee for Aeronautics
Cleveland, Ohio, March 22, 1954.

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TABLE I. - STABILIZER PRESSURE COEFFICIENTS

(a) Mach number 1.8, stabilizer in aft position, deflection angle = 0°

Tail station	Tube[1]	Percent chord	Jet pressure ratio, P_1/p_0			
			Jet-off	4	6	9
			Pressure coefficient			
11.29	a	8.6	0.0507	0.0506	0.0499	0.0524
	a'		.0540	.0531	.0515	.0606
	b	19.9	-.0016	-.0106	-.0106	.0122
	b'		.0229	.0204	.0204	.0343
	c	56.2	-.0786	-.0727	-.0769	-.0827
	c'		-.0663	-.0555	-.0621	-.0647
	d	76.5	-.0876	-.0923	-.0842	-.0753
	d'		-.0974	-.0955	-.0990	-.0958
	e	85.5	-.1056	-.1004	-.1006	-.0982
	e'		-.1007	-.1015	-.1014	-.0917
7.09	f	4.96	0.0515	0.0498	0.0499	0.0606
	f'		.0401	.0367	.0376	.0556
	g	12.9	-.0040	.0008	.0065	-.0008
	g'		.0098	.0114	.01[illegible]6	.0376
	h	45.6	-.0728	-.0792	-.0810	-.0859
	h'		-.0507	-.0571	-.0589	-.0532
	i	60.7	-.1130	-.1160	-.1137	-.1146
	i'		-.0622	-.0710	-.0695	-.0745
	j	77.8	-.1433	-.1413	-.1407	-.1449
	j'		-.0925	-.0939	-.0941	-.0950
	k	86.1	-.1384	-.1380	-.1407	-.1400
	k'		-.1154	-.1160	-.1137	-.1146
	l	89.8	-.1859	-.1879	-.1882	-.1850
	l'		-.1228	-.1217	-.1219	-.1212
5.50	m	66.5	-0.2063	-0.2066	-0.2070	-0.2055
	m'		-.1285	-.1290	-.1292	-.1318
	n	89.2	-.2047	-.2475	-.2446	-.1146
	n'		-.1547	-.1544	-.1554	-.1523
4.50	o	4.65	0.1957	------	------	------
	o'		.0851	------	------	------
	p	14.8	.0155	------	------	------
	p'		.0262	------	------	------
	q	43.7	-.1007	-.1094	-.1096	-.1146
	q'		-.0704	-.0767	-.0761	-.0884
	r	57.6	-.2194	-.2205	-.2201	-.2170
	r'		-.1654	-.1666	-.1661	-.1678
	s	71.5	-.2481	-.2622	-.2618	-.2211
	s'		-.1965	-.1952	-.1996	-.1973
	t	90.3	-.1826	-.1748	-.1603	-.0925
	t'		-.1482	-.1486	-.1530	-.1285
3.85	u	74.7	-0.1990	-0.2246	-0.2225	-0.1269
	u'		-.0745	-.1102	-.1080	-.0532
	v	91.9	-.1433	-.1266	-.1243	-.0278
	v'		-.1425	-.1601	-.1587	-.0573

[1]Prime symbols denote static orifices on suction surface.

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TABLE I. - Continued. STABILIZER PRESSURE COEFFICIENTS

(b) Mach number 1.8, stabilizer in aft position, deflection angle = 5°

Tail station	Tube[1]	Percent chord	Jet pressure ratio, P_1/p_0			
			Jet-off	4	6	9
			Pressure coefficient			
11.29	a	8.6	0.1852	0.1867	0.1818	0.1871
	a'		-.1229	-.1253	-.1245	-.1231
	b	19.9	.1187	.1203	.1279	.1489
	b'		.5132	.6282	.5656	.4334
	c	56.2	.0157	.0149	.0124	.0099
	c'		-.1661	-.1510	-.1652	-.1680
	d	76.5	-.0315	-.0290	-.0373	-.0374
	d'		-.1719	-.1543	-.1644	-.1630
	e	85.5	-.0382	-.0398	-.0490	-.0490
	e'		-.1553	-.1535	-.1470	-.1405
7.09	f	4.96	0.1835	0.1842	0.1827	0.1846
	f'		-.1187	-.1120	-.1187	-.1198
	g	12.9	.1112	.1136	.1088	.1089
	g'		-.1046	-.1020	-.1063	-.1031
	h	45.6	-.0091	-.0165	-.0348	-.0391
	h'		-.0722	-.0663	-.0822	-.0856
	i	60.7	------	------	------	------
	i'		-.1162	-.1136	-.1245	-.1264
	j	77.8	------	------	------	------
	j'		-.0697	-.0232	-.0465	-.0931
	k	86.1	-.0897	-.0921	-.0955	-.0890
	k'		-.1694	-.1775	-.1760	-.1722
	l	89.8	-.1403	-.1352	-.1420	-.1439
	l'		------	------	------	------
5.50	m	66.5	-0.1611	-0.1551	-0.1619	-0.1630
	m'		-.1519	-.1601	-.1561	-.1547
	n	89.2	-.2009	-.1908	-.2009	-.2029
	n'		-.2217	-.2141	-.2192	-.2212
4.50	o	4.65	------	------	------	------
	o'		0.0074	------	------	------
	p	14.8	.0880	------	------	------
	p'		------	------	------	------
	q	43.7	-.0232	-.0282	-.0390	-.0449
	q'		-.1146	-.1029	-.1212	-.1198
	r	57.6	-.1818	-.1717	-.1810	-.1838
	r'		-.1877	-.1809	-.1868	-.1863
	s	71.5	-.2267	-.2165	-.2267	-.2237
	s'		-.2209	-.2207	-.2217	-.2237
	t	90.3	-.1777	-.1717	-.1669	-.0940
	t'		-.1810	-.1941	-.1619	-.0931
3.85	u	74.7	-0.2101	-0.2000	-0.2109	-0.2121
	u'		-.2117	-.2008	-.2093	-.2079
	v	91.9	-.1328	-.1468	-.0988	-.0673
	v'		-.1503	-.1659	-.1063	-.0457

[1]Prime symbols denote static orifices on suction surface.

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TABLE I. - Continued. STABILIZER PRESSURE COEFFICIENTS

(c) Mach number 1.8, stabilizer in aft position, deflection angle = 10°

Tail station	Tube[1]	Percent chord	Jet pressure ratio, P_1/p_0			
			Jet-off	4	6	9
			Pressure coefficient			
11.29	a	8.6	0.3176	0.3228	0.3317	0.3303
	a'		-.2358	-.2338	-.2354	-.2382
	b	19.9	.2593	.2564	.2564	.2552
	b'		-.2285	-.2233	-.2297	-.2318
	c	56.2	.1053	.1051	.1027	.1001
	c'		-.2560	-.2491	-.2605	-.2633
	d	76.5	.0591	.0606	.0590	.0581
	d'		-.2617	-.2564	-.2629	-.2633
	e	85.5	.0534	.0525	.0550	.0525
	e'		-.2471	-.2435	-.2516	-.2520
7.09	f	4.96	0.3257	0.3228	0.3260	0.3247
	f'		.1709	.2168	.1343	.1348
	g	12.9	.2269	.2257	.2241	.2245
	g'		-.2139	-.2095	-.2160	-.2189
	h	45.6	.0786	.0784	.0800	.0791
	h'		-.1434	-.1391	-.1423	-.1429
	i	60.7	.0089	.0080	.0080	.0080
	i'		-.1077	-.0817	-.1286	-.1284
	j	77.8	-.0494	-.0469	-.0493	-.0500
	j'		-.1912	-.1893	-.1957	-.2019
	k	86.1	-.0356	-.0372	-.0372	-.0395
	k'		-.2082	-.2071	-.2095	-.2124
	l	89.8	-.0794	-.0776	-.0817	-.0815
	l'		-.2139	-.2119	-.2160	-.2180
5.50	m	66.5	-0.1110	-0.1092	-0.1140	-0.1147
	m'		-.2179	-.2144	-.2241	-.2285
	n	89.2	-.1450	-.1415	-.1472	-.1478
	n'		-.2309	-.2289	-.2313	-.1736
4.50	o	4.65	0.2017	------	------	------
	o'		-.0721	------	------	------
	p	14.8	.1636	------	------	------
	p'		-.0316	------	------	------
	q	43.7	.0316	.0275	.0283	.0250
	q'		-.1717	-.1755	-.1982	-.2245
	r	57.6	-.1377	-.1343	-.1399	-.1421
	r'		-.2455	-.2370	-.2516	-.2568
	s	71.5	-.1831	-.1779	-.1836	-.1857
	s'		-.2479	-.2451	-.2508	-.2463
	t	90.3	-.1531	-.1488	-.1626	-.1599
	t'		-.2139	-.2176	-.1294	-.0597
3.85	u	74.7	-0.1896	-0.1868	-0.1949	-0.1978
	u'		-.2277	-.2208	-.2297	-.1655
	v	91.9	-.1758	-.1618	-.1650	-.0920
	v'		------	------	------	------

[1]Prime symbols denote static orifices on suction surface.

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TABLE I. - Continued. STABILIZER PRESSURE COEFFICIENTS

(d) Mach number 1.8, stabilizer in fore position, deflection angle = 10°

Tail station	Tube[1]	Percent chord	Jet pressure ratio, P_1/p_0		
			Jet-off	4	6
			Pressure coefficient		
11.29	a	8.6	0.2999	0.3058	0.3170
	a'		-.2373	-.2409	-.2375
	b	19.9	.2381	.2457	.2479
	b'		-.2397	-.2417	-.2367
	c	56.2	.0809	.0768	.0778
	c'		-.2646	-.2690	-.2616
	d	76.5	.0545	.0520	.0537
	d'		-.2582	-.2610	-.2568
	e	85.5	.0561	.0528	.0489
	e'		-.2638	-.2650	-.2592
7.09	f	4.96	0.3143	0.3122	0.3138
	f'		-.2213	-.2249	-.2207
	g	12.9	.2149	.2121	.2191
	g'		-.2181	-.2193	-.2158
	h	45.6	.0625	.0576	.0561
	h'		-.1419	-.1409	-.1372
	i	60.7	.0368	.0376	.0393
	i'		-.1844	-.1849	-.1837
	j	77.8	------	.0248	-.0208
	j'		-.1788	-.1793	-.1789
	k	86.1	-.0008	-.0008	-.0016
	k'		-.1924	-.1945	-.1926
	l	89.8	-.0433	-.0416	-.0385
	l'		-.1956	-.1985	-.1950
5.50	m	66.5	-0.0184	-0.0176	-0.0184
	m'		-.1924	-.1921	-.1910
	n	89.2	-.1323	-.1329	-.1292
	n'		-.2237	-.2353	-.2126
4.50	o	4.65	0.1748	------	------
	o'		-.0793	------	------
	p	14.8	.1427	------	------
	p'		-.0441	------	------
	q	43.7	.0842	.0800	.0754
	q'		-.1836	-.1857	-.2118
	r	57.6	.0120	.0104	.0112
	r'		-.1932	-.1993	-.1934
	s	71.5	-.1242	-.1257	-.1211
	s'		-.2373	-.2433	-.2335
	t	90.3	-.1740	-.1737	-.1701
	t'		-.1972	-.2217	-.1605
3.85	u	74.7	-0.2085	-0.2129	-0.2014
	u'		-.2510	-.2626	-.2255
	v	91.9	-.1780	-.1793	-.1621
	v'		-.1972	-.2241	-.1476

[1]Prime symbols denote static orifices on suction surface.

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TABLE I. - Continued. STABILIZER PRESSURE COEFFICIENTS

(e) Mach number 0.63, stabilizer in aft position, deflection angle = 0°

Tail station	Tube[1]	Percent chord	Jet pressure ratio, P_1/p_0				
			Jet-off	2	2.5	3	3.5
			Pressure coefficient				
11.29	a	8.6	-0.1951	-0.1866	-0.1795	-0.1781	-0.1757
	a'		-.1271	-.1250	-.1214	-.1269	-.1247
	b	19.9	------	------	------	------	------
	b'		-.1498	-.1461	-.1443	-.1446	-.1441
	c	56.2	-.1637	-.1549	-.1496	-.1516	-.1511
	c'		-.1324	-.1267	-.1214	-.1146	-.1142
	d	76.5	-.0505	-.0404	-.0404	-.0440	-.0404
	d'		-.0418	-.0352	-.0387	-.0423	-.0333
	e	85.5	-.0069	-.0052	-.0052	-.0052	-.0035
	e'		.0052	-.0035	------	------	-.0035
7.09	f	4.96	-0.2317	-0.2288	-0.2235	-0.2204	-0.2161
	f'		-.1585	-.1549	-.1566	-.1622	-.1564
	g	12.9	-.2770	-.2658	-.2658	-.2627	-.2636
	g'		-.1933	-.1919	-.1883	-.1887	-.1845
	h	45.6	-.2700	-.2464	-.2411	-.2433	-.2390
	h'		-.2177	-.1989	-.1883	-.1887	-.1880
	i	60.7	-.1777	-.1584	-.1549	-.1569	-.1511
	i'		-.1254	-.1144	-.1126	-.1146	-.1089
	j	77.8	-.0487	-.0246	-.0264	-.0229	-.0404
	j'		-.0313	-.0105	-.0105	-.0105	-.0087
	k	86.1	.0034	.0246	.0281	.0264	.0281
	k'		.0121	.0316	.0316	.0299	.0316
	l	89.8	.0348	.0369	-.0088	.0370	.0492
	l'		.0348	.0563	.0510	.0511	.0509
5.50	m	66.5	-0.1463	-0.1267	-0.1214	-0.1199	-0.1177
	m'		-.1219	-.1091	-.1056	-.1022	-.1001
	n	89.2	.0365	.0739	.0757	.0740	.0808
	n'		.0296	------	.0457	.0599	-.0386
4.50	o	4.65	-0.0383	------	------	------	------
	o'		-.0662	------	------	------	------
	p	14.8	-.1289	------	------	------	------
	p'		-.0975	------	------	------	------
	q	43.7	-.5714	-.5510	-.5457	-.5485	-.5606
	q'		-.3937	-.3750	-.3679	-.3703	-.3620
	r	57.6	-.3031	-.2799	-.2764	-.2751	-.2759
	r'		-.2665	-.2464	-.2429	-.2433	-.2302
	s	71.5	-.1080	-.0880	-.0809	-.0723	-.0687
	s'		-.1097	-.0968	-.0845	-.0864	-.0773
	t	90.3	.0487	.0862	.0915	.0934	.0931
	t'		.0209	.0563	.0580	.0564	.0562
3.85	u	74.7	-0.1045	-0.0845	-0.0774	-0.0723	-0.0597
	u'		------	------	------	------	------
	v	91.9	.0400	.0686	.0757	.0740	.0755
	v'		.0243	.0598	.0633	.0652	.1247

[1]Prime symbols denote static orifices on suction surface.

[redacted]

TABLE I. - Continued. STABILIZER PRESSURE COEFFICIENTS

(f) Mach number 0.63, stabilizer in aft position, deflection angle = 10°

Tail station	Tube[1]	Percent chord	Jet pressure ratio, P_1/p_0				
			Jet-off	2	2.5	3	3.5
			Pressure coefficient				
11.29	a	8.6	0.3054	0.3162	0.3104	0.3139	0.3156
	a'		------	------	------	------	------
	b	19.9	.1727	.1908	.1851	.1851	.1904
	b'		------	------	------	------	------
	c	56.2	.0122	.0300	.0299	.0317	.0317
	c'		------	------	------	------	------
	d	76.5	.0104	.0300	.0282	.0335	.0317
	d'		-.3438	-.2844	-.2892	-.2892	-.2804
	e	85.5	.0209	.0318	.0239	.0299	.0317
	e'		-.1832	-.1024	-.1040	-.1058	-.1022
7.09	f	4.96	0.2687	0.2809	0.2733	0.2804	0.2786
	f'		------	------	------	------	------
	g	12.9	.1291	.1484	.1481	.1481	.1587
	g'		------	------	------	------	------
	h	45.6	-.0366	-.0229	-.0246	-.0176	-.0194
	h'		-.4048	-.3480	-.3474	-.3456	-.3421
	i	60.7	-.0575	-.0159	-.0141	-.0088	-.0105
	i'		------	------	-.5925	-.5537	-.5432
	j	77.8	.0226	.0512	.0423	.0458	.0529
	j'		-.1116	-.0653	-.0670	-.0652	-.0670
	k	86.1	.0401	.0724	.0670	.0828	.0776
	k'		-.0418	-.0053	-.0070	-.0052	-.0070
	l	89.8	-.7678	.0883	.0052	.0634	.0917
	l'		-.0087	.0265	.0264	.0246	.0282
5.50	m	66.5	-0.0506	-0.0229	-0.0246	-0.0211	-0.0176
	m'		-.2565	-.2226	-.1975	-.1940	-.1887
	n	89.2	.0575	.0936	.0899	.0970	.0987
	n'		-.0418	.0212	.0105	.0211	.0194
4.50	o	4.65	0.2565	------	------	------	------
	o'		------	------	------	------	------
	p	14.8	.1780	------	------	------	------
	p'		-.3909	------	------	------	------
	q	43.7	-.3507	-.3091	-.3139	-.3086	-.3051
	q'		-.6876	-.5918	-.5820	-.5943	-.5837
	r	57.6	-.2181	-.1643	-.1675	-.1640	-.1657
	r'		-.4310	-.3392	-.3368	-.3350	-.3333
	s	71.5	-.0680	-.0194	-.0211	-.0158	-.0105
	s'		-.2181	-.1678	-.1622	-.1552	-.1463
	t	90.3	.0418	.0883	.0846	.0934	.1022
	t'		-.0209	.0141	.0123	-.1693	.0229
3.85	u	74.7	-0.4363	-0.0318	-0.0317	-0.0282	-0.0246
	u'		-.1902	-.1219	-.1216	-.1269	-.1216
	v	91.9	------	.0600	.0511	.0564	.0687
	v'		.0942	.0742	.0705	.0687	.0723

[1]Prime symbols denote static orifices on suction surface.

[redacted]

TABLE I. - Concluded. STABILIZER PRESSURE COEFFICIENTS

(g) Mach number 0.63, stabilizer in fore position, deflection angle = 10°

Tail station	Tube[1]	Percent chord	Jet pressure ratio, P_1/p_0				
			Jet-off	2	2.5	3	3.5
			Pressure coefficient				
11.29	a	8.6	0.3067	0.3052	0.3106	0.3035	0.3087
	a'		------	------	------	------	------
	b	19.9	.1733	.1807	.1849	.1807	.1824
	b'		------	------	------	------	------
	c	56.2	.0173	.0228	.0244	.0228	.0210
	c'		-.7400	-.7491	-.7417	-.7438	-.7421
	d	76.5	.0173	.0228	.0226	.0245	.0210
	d'		-.2859	-.2736	-.2722	-.2684	-.2666
	e	85.5	.0225	.0228	.0244	.0245	.0263
	e'		-.1074	-.0982	-.0977	-.0964	-.1122
7.09	f	4.96	0.2928	0.2947	0.2366	0.2912	0.2982
	f'		------	------	------	------	------
	g	12.9	.1681	.1684	.1727	.1736	.1719
	g'		------	------	------	------	------
	h	45.6	-.0641	-.0473	-.0488	-.0508	-.0473
	h'		-.4228	-.4210	-.4118	-.4175	-.4105
	i	60.7	-.0641	-.0473	-.0488	-.0491	-.0491
	i'		-.2963	-.2824	-.2774	-.2789	-.2789
	j	77.8	-.5129	-.1859	.0279	-.0543	------
	j'		-.1230	-.1070	-.1047	-.1105	-.1087
	k	86.1	.0311	.0561	.0558	.0526	.0543
	k'		-.0537	-.0385	-.0383	-.0421	-.0403
	l	89.8	.0606	.0578	.0820	.0771	.0719
	l'		-.0173	-.0017	.0034	-.0017	------
5.50	m	66.5	-0.1109	-0.0894	-0.0890	-0.0912	-0.0877
	m'		-.3154	-.3000	-.2949	-.2864	-.2894
	n	89.2	.0433	.0684	.0715	.0701	.0684
	n'		-.0467	-.0210	-.0226	-.0228	-.0298
4.50	o	4.65	0.2686	------	------	------	------
	o'		-.4592	------	------	------	------
	p	14.8	.1941	------	------	------	------
	p'		-.3240	------	------	------	------
	q	43.7	-.1005	-.0982	-.0959	-.1157	-.1035
	q'		-.5372	-.5315	-.5253	-.5315	-.5315
	r	57.6	-.3535	-.3350	-.3263	-.3333	-.3298
	r'		-.5563	-.5421	-.5357	-.5333	-.5298
	s	71.5	-.1317	-.1105	-.1082	-.1105	-.1122
	s'		-.2928	-.2859	-.2792	-.2736	-.2701
	t	90.3	.0294	.0631	.0663	.0614	.0631
	t'		-.0641	-.0350	-.0349	-.0350	-.0298
3.85	u	74.7	-0.1265	-0.1105	-0.1029	-0.1105	-0.1070
	u'		-.2391	-.2333	-.2233	-.2263	-.2421
	v	91.9	.0051	.0438	.0418	.0368	.0456
	v'		-.0606	-.0333	-.0314	-.0298	-.0280

[1]Prime symbols denote static orifices on suction surface.

[redacted]

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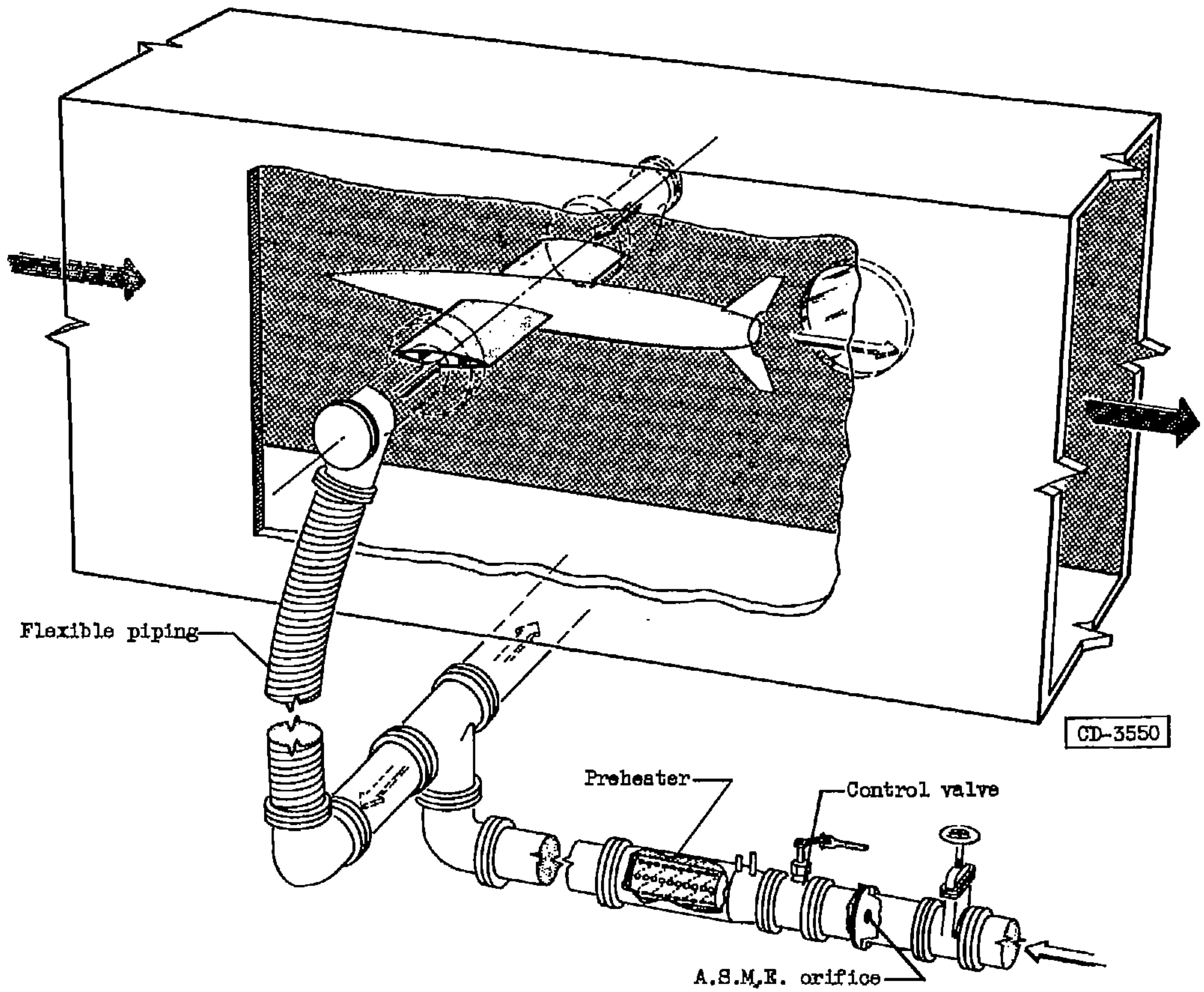

Figure 1. - Schematic diagram of jet-exit model installed in 8- by 6-foot supersonic wind tunnel.

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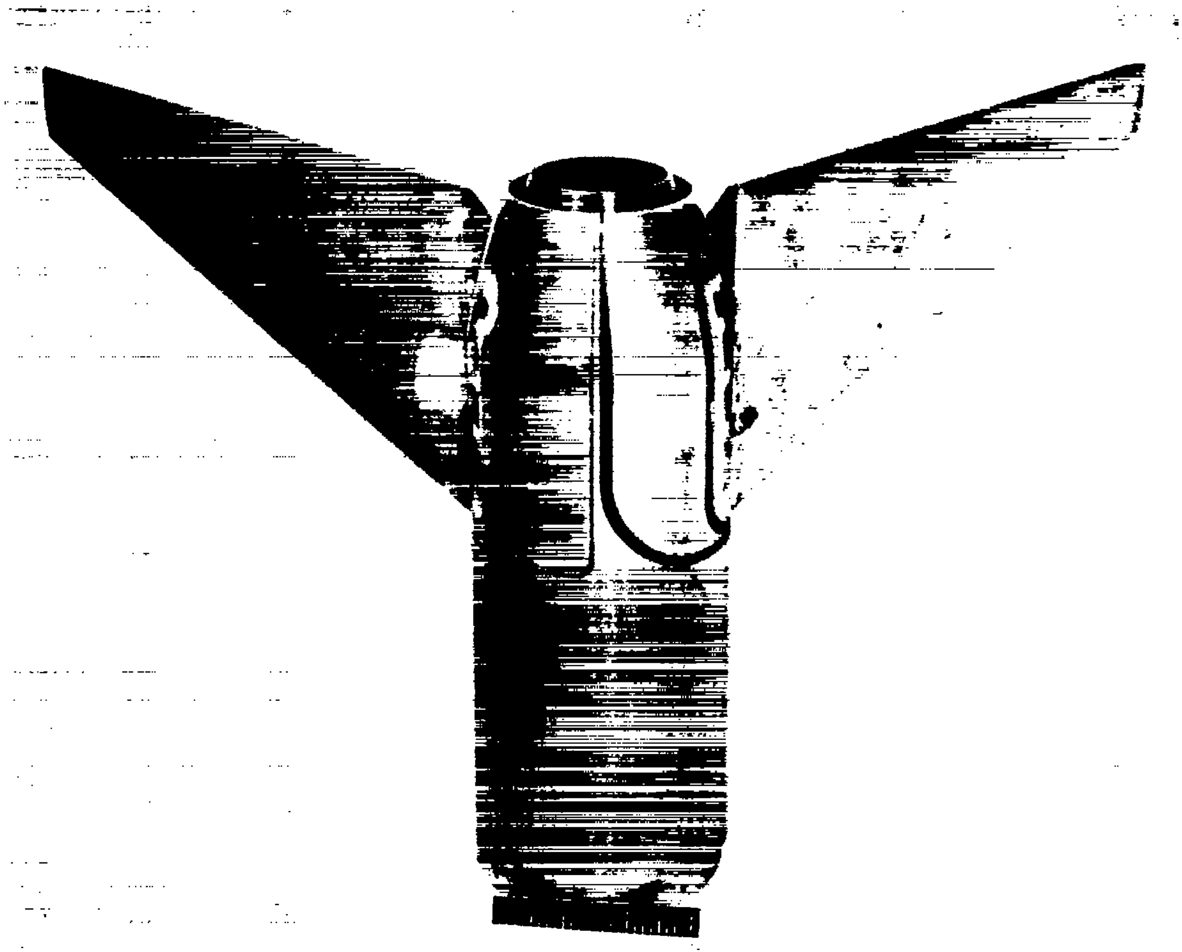

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Figure 2. - Photograph of stabilizers mounted on afterbody.

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Location of static orifices

Tail station	Tube	Percent chord
3.85	u v	74.7 91.1
4.50	o p q r s t	4.65 14.8 43.7 57.6 71.5 90.3
5.50	m n	66.5 89.2
7.09	f g h i j k l	4.96 12.9 45.6 60.7 77.8 86.1 89.8
11.29	a b c d e	8.6 19.9 56.2 76.5 85.5

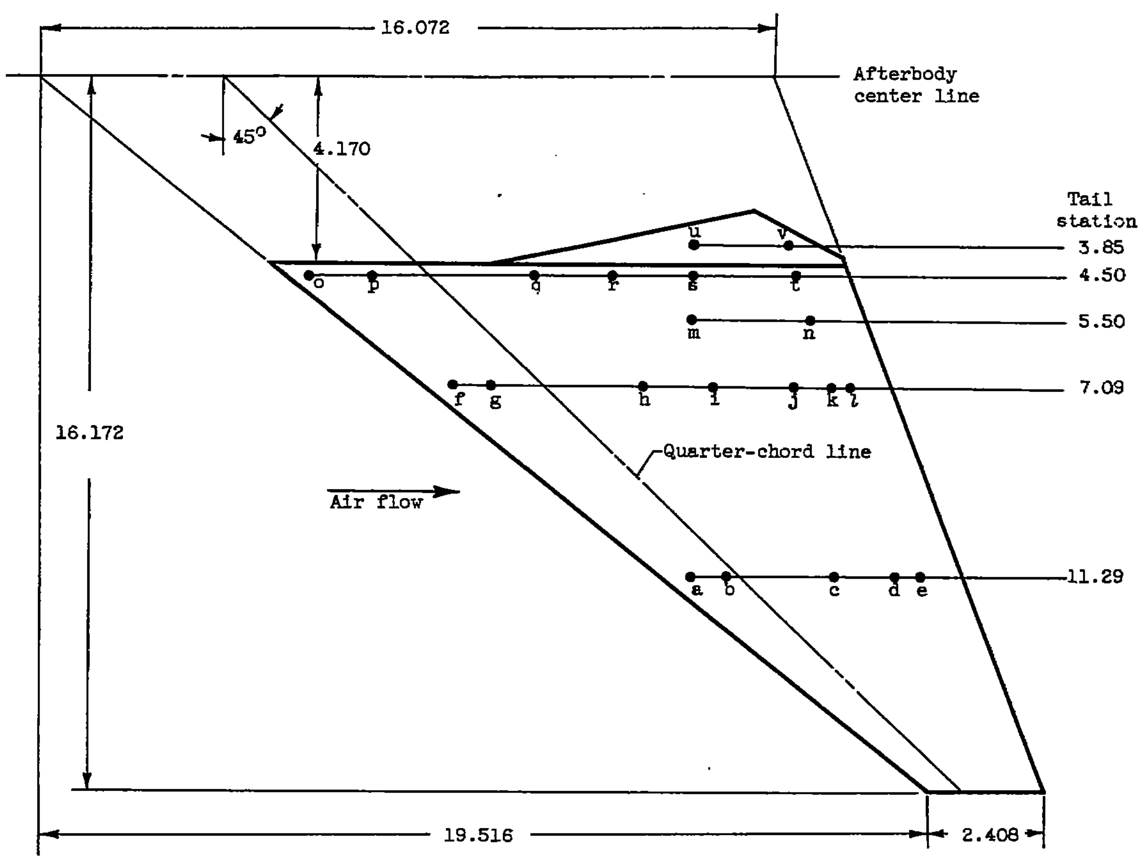

Figure 3. - Schematic diagram of horizontal stabilizer. (All dimensions in inches.)

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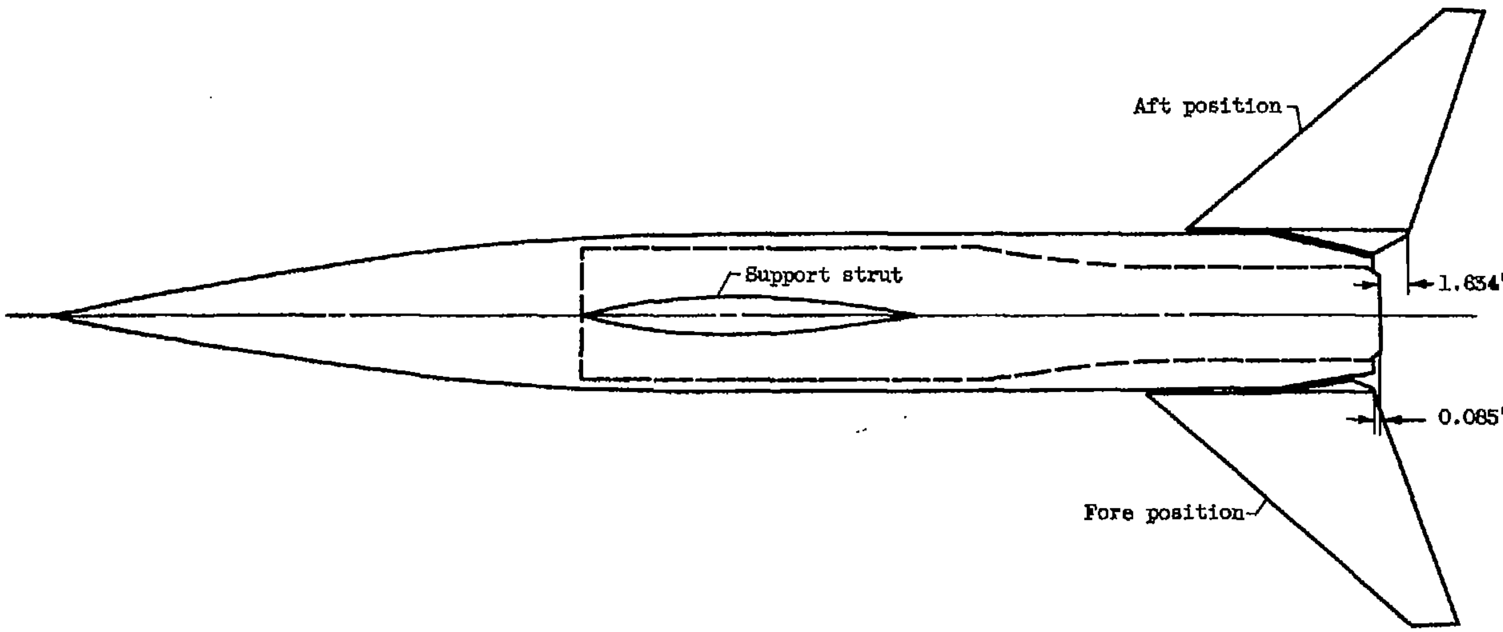

Figure 4. - Model with horizontal stabilizer in two positions.

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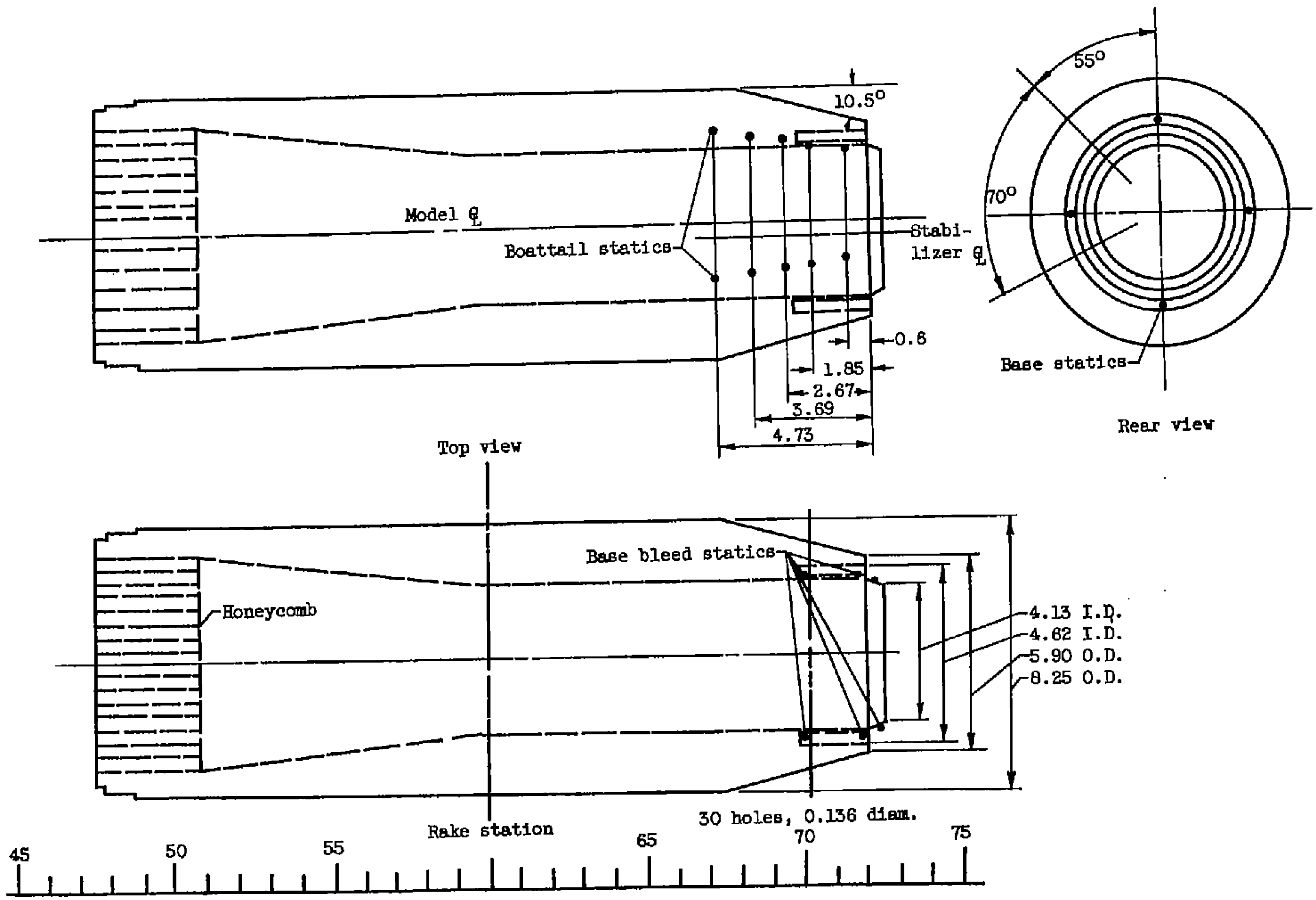

Figure 5. - Afterbody instrumentation. (All dimensions in inches.)

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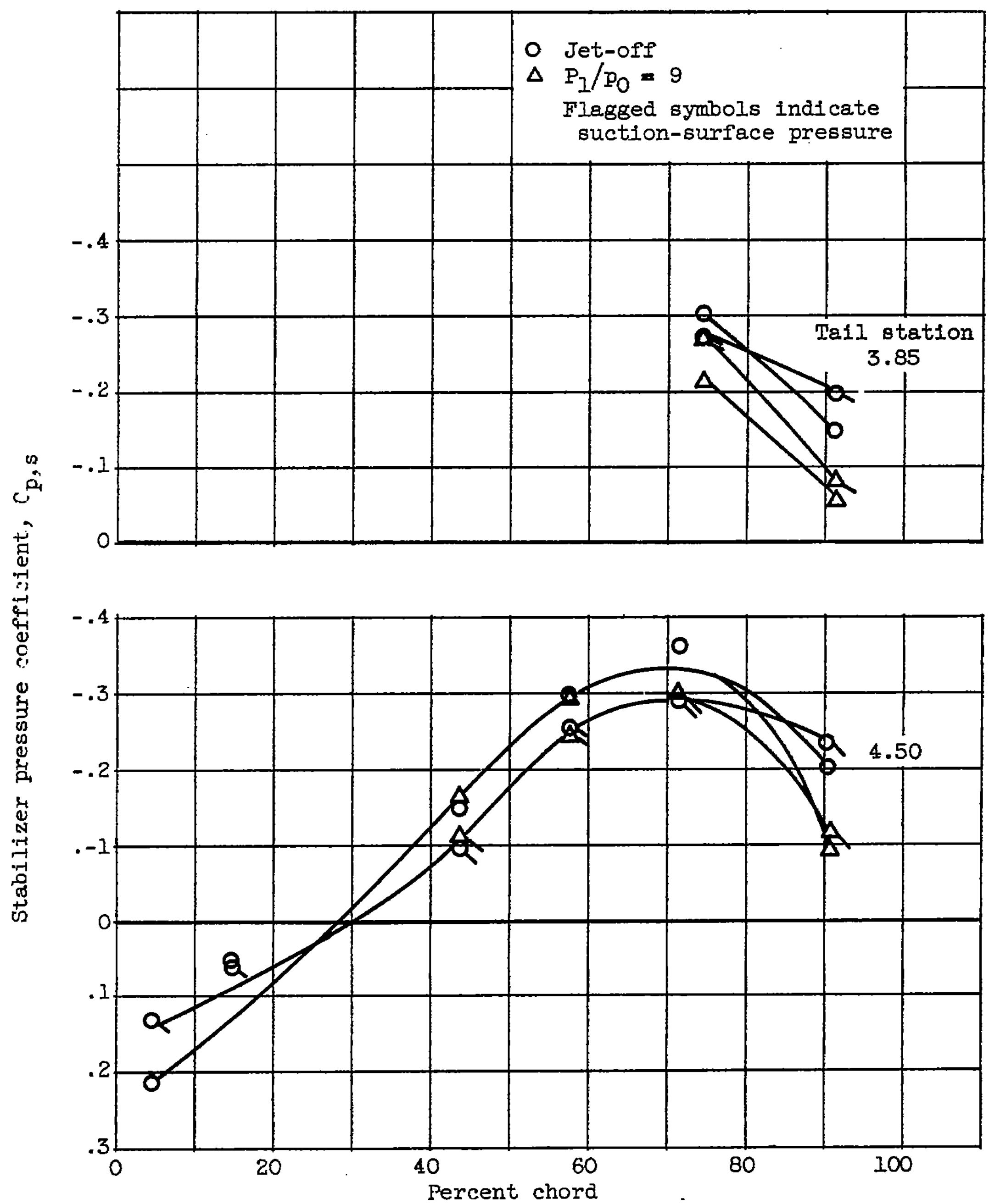

(a) Stabilizer in aft position. Deflection angle, 0°.

Figure 6. - Effect of jet pressure ratio on pressure distribution of stabilizer at free-stream Mach number of 1.5.

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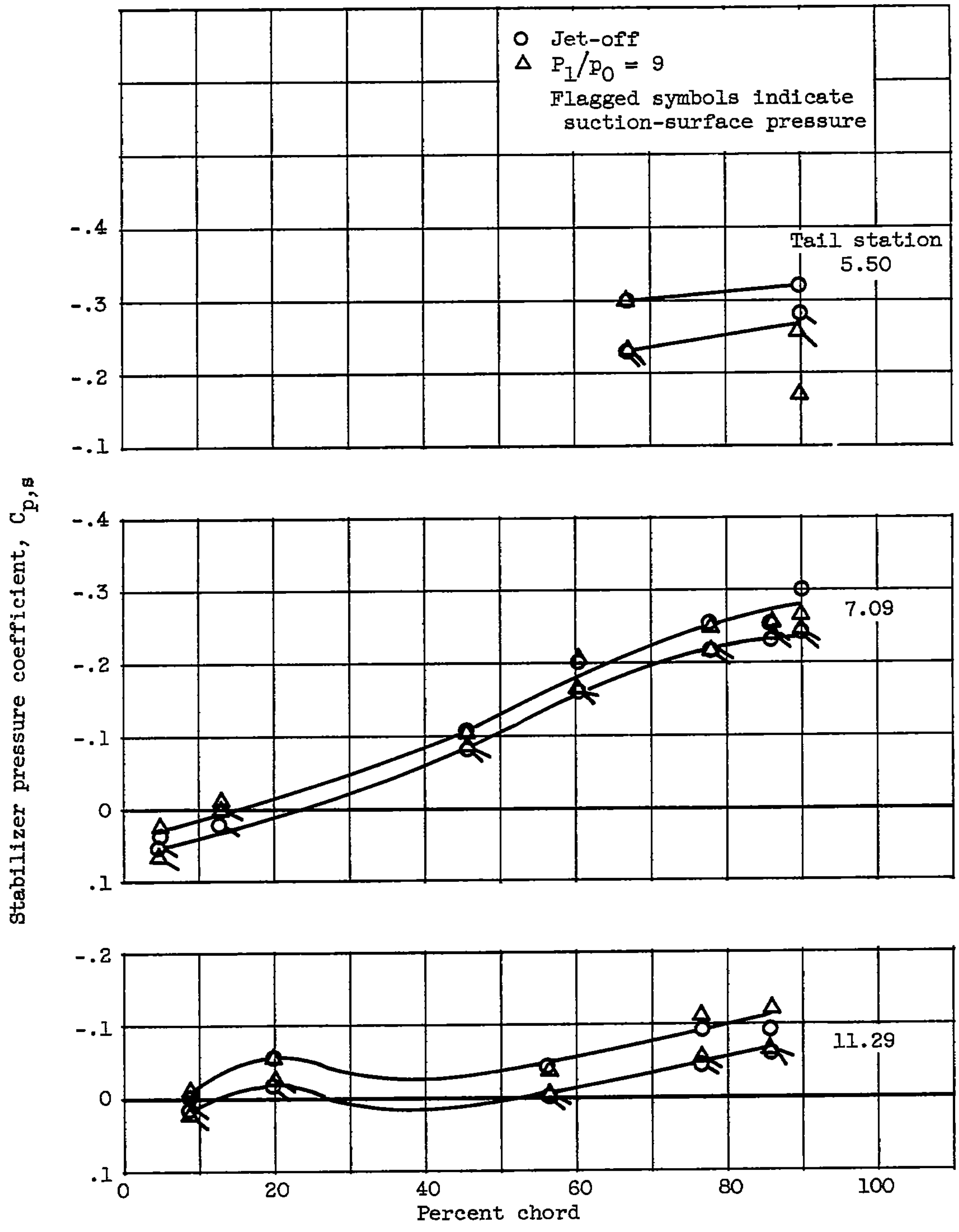
CW-3 back



(a) Concluded. Stabilizer in aft position. Deflection angle, 0°.

Figure 6. - Continued. Effect of jet pressure ratio on pressure distribution of stabilizer at free-stream Mach number of 1.5.

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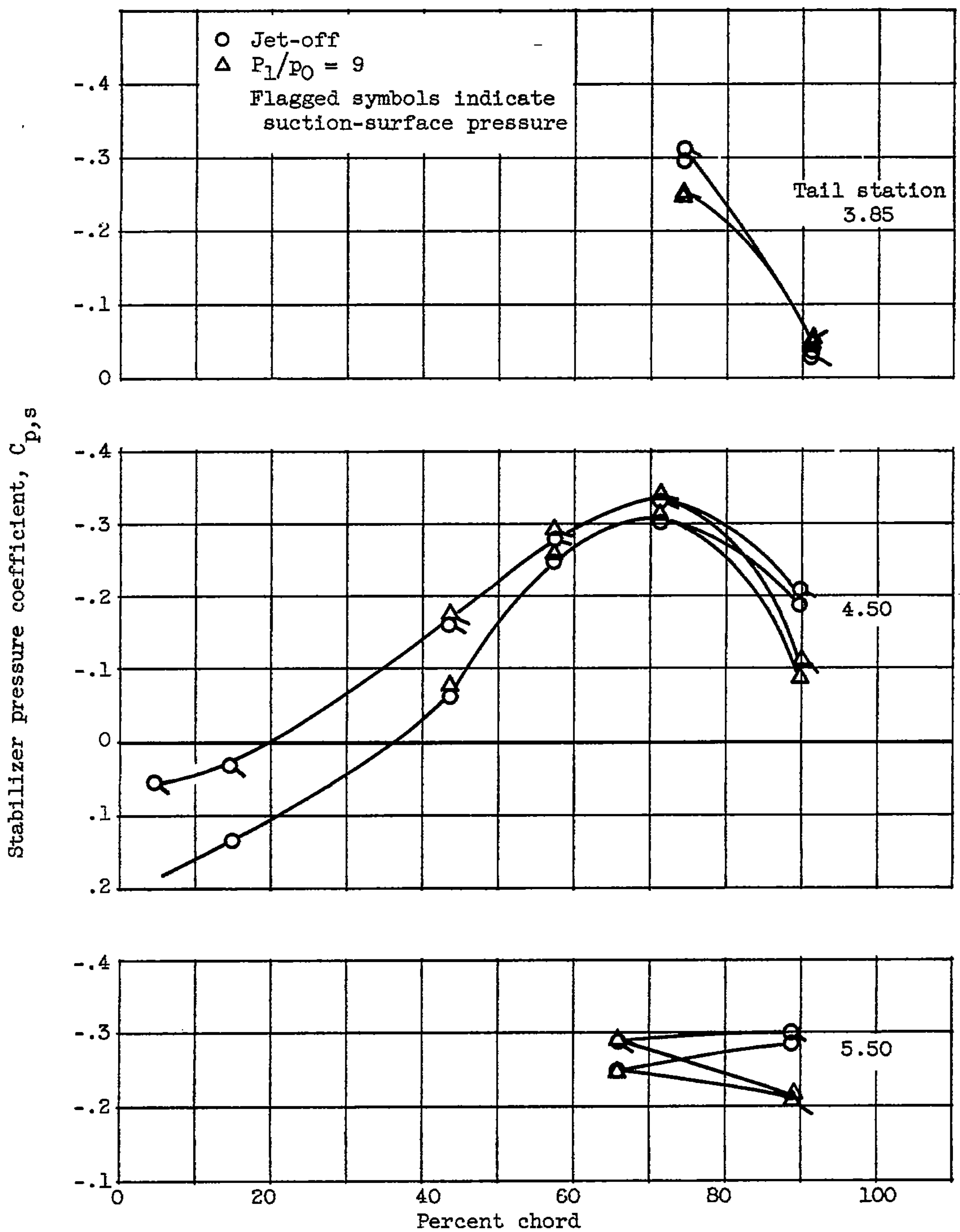

(b) Stabilizer in aft position. Deflection angle, 5°.

Figure 6. - Continued. Effect of jet pressure ratio on pressure distribution of stabilizer at free-stream Mach number of 1.5.

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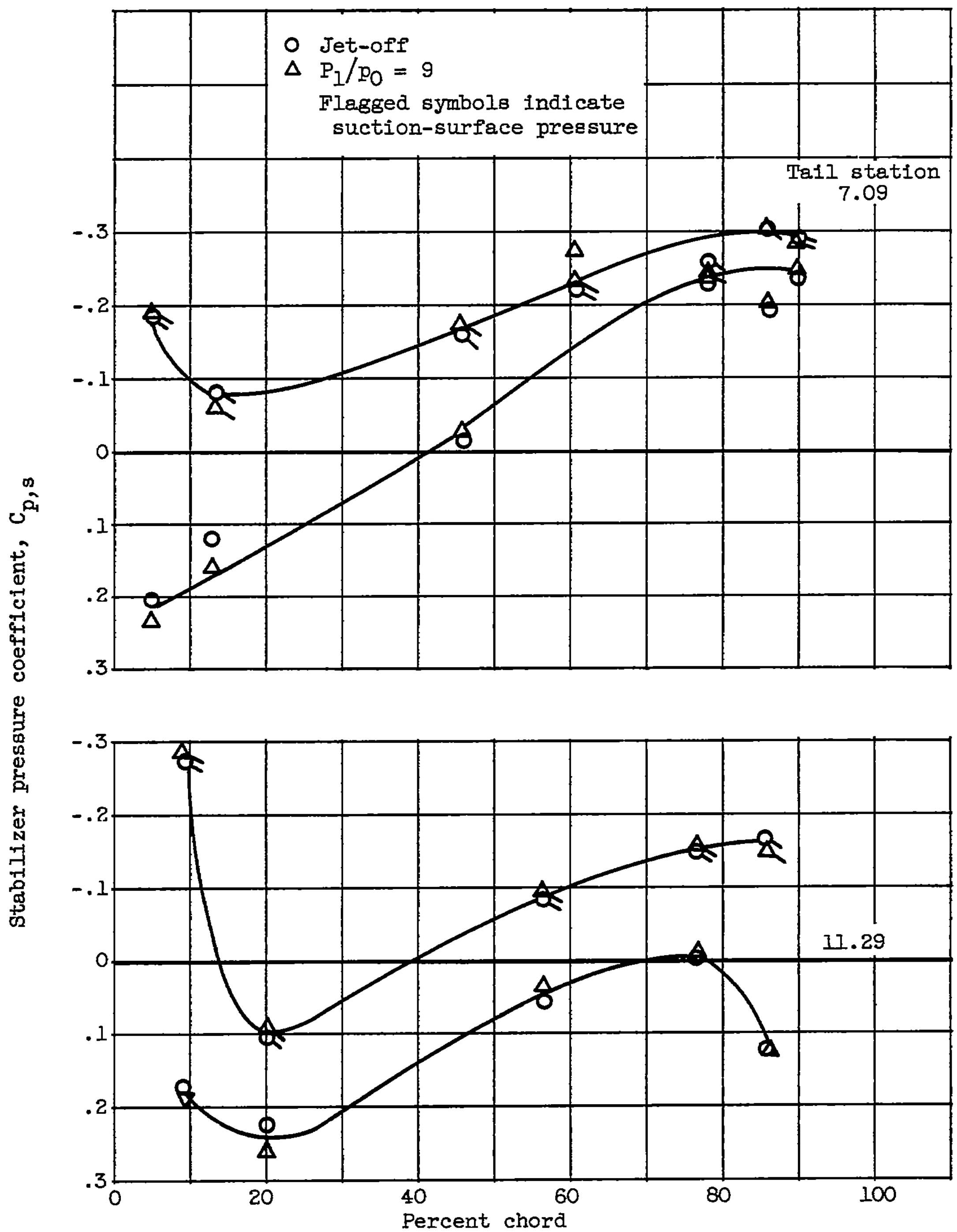

(b) Concluded. Stabilizer in aft position. Deflection angle, 5°.

Figure 6. - Continued. Effect of jet pressure ratio on pressure distribution of stabilizer at free-stream Mach number of 1.5.

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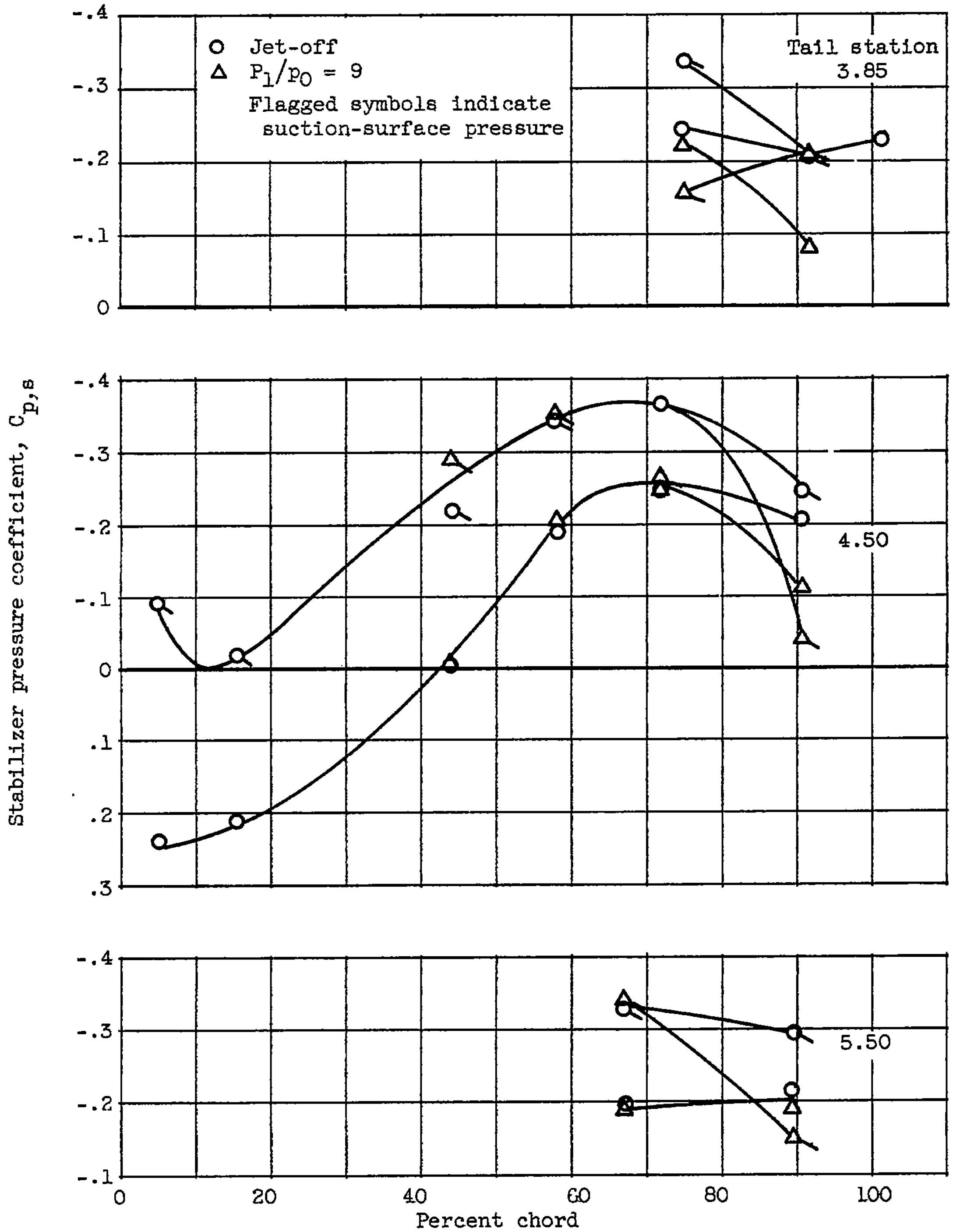

(c) Stabilizer in aft position. Deflection angle, 10°.

Figure 6. - Continued. Effect of jet pressure ratio on pressure distribution of stabilizer at free-stream Mach number of 1.5.

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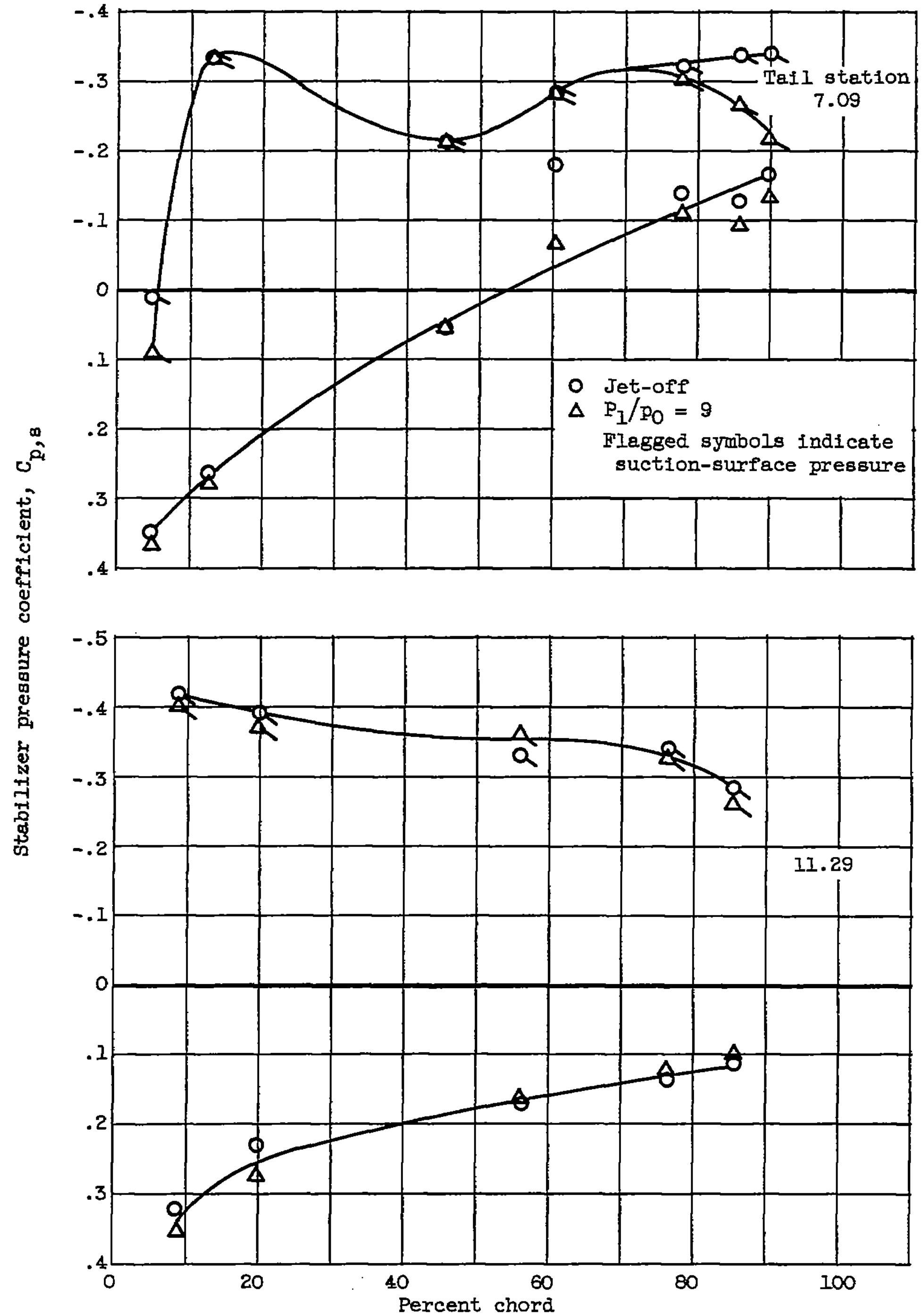

(c) Concluded. Stabilizer in aft position. Deflection angle, 10°.

Figure 6. - Continued. Effect of jet pressure ratio on pressure distribution of stabilizer at free-stream Mach number of 1.5.

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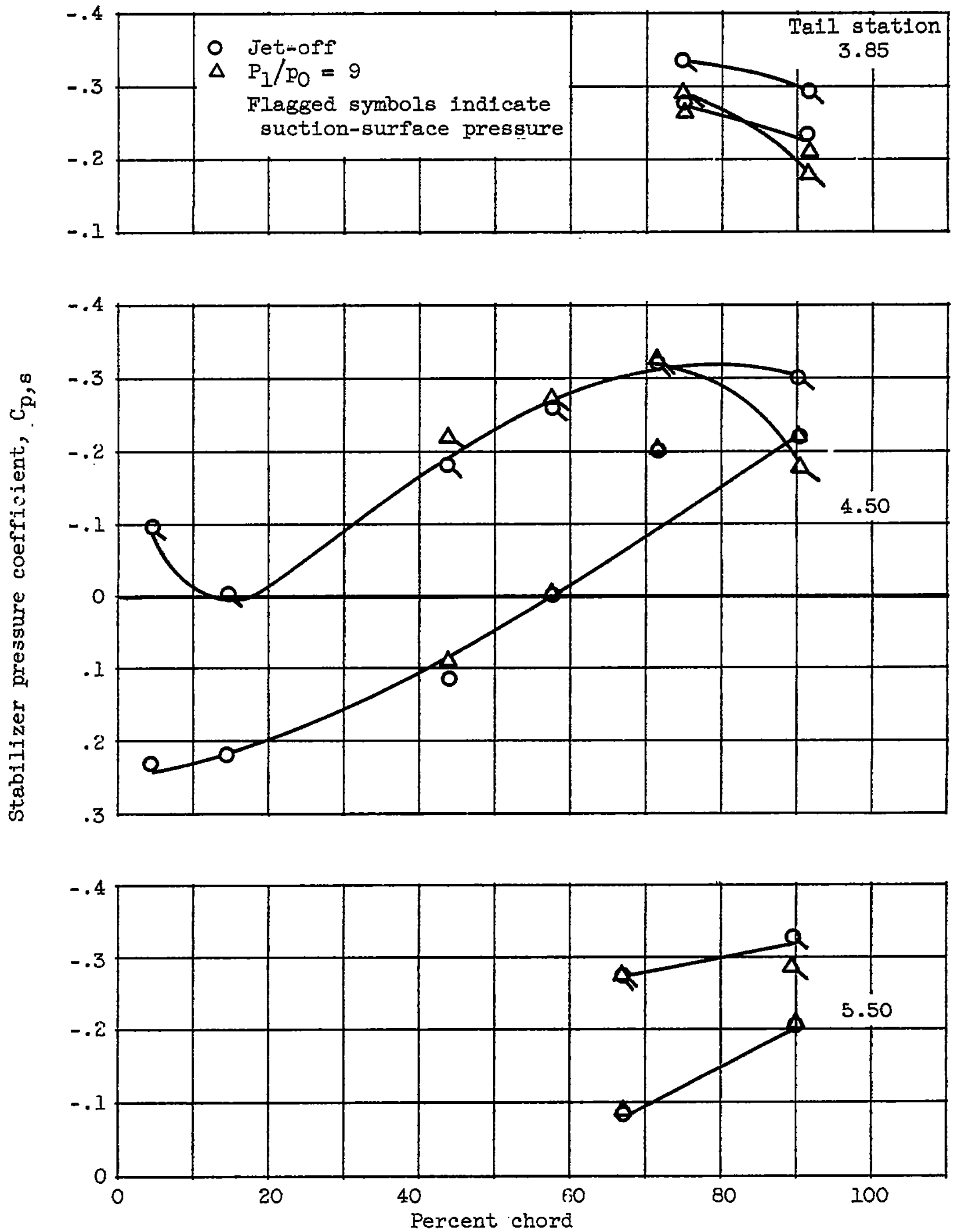

(d) Stabilizer in fore position. Deflection angle, 10°.

Figure 6. - Continued. Effect of jet pressure ratio on pressure distribution of stabilizer at free-stream Mach number of 1.5.

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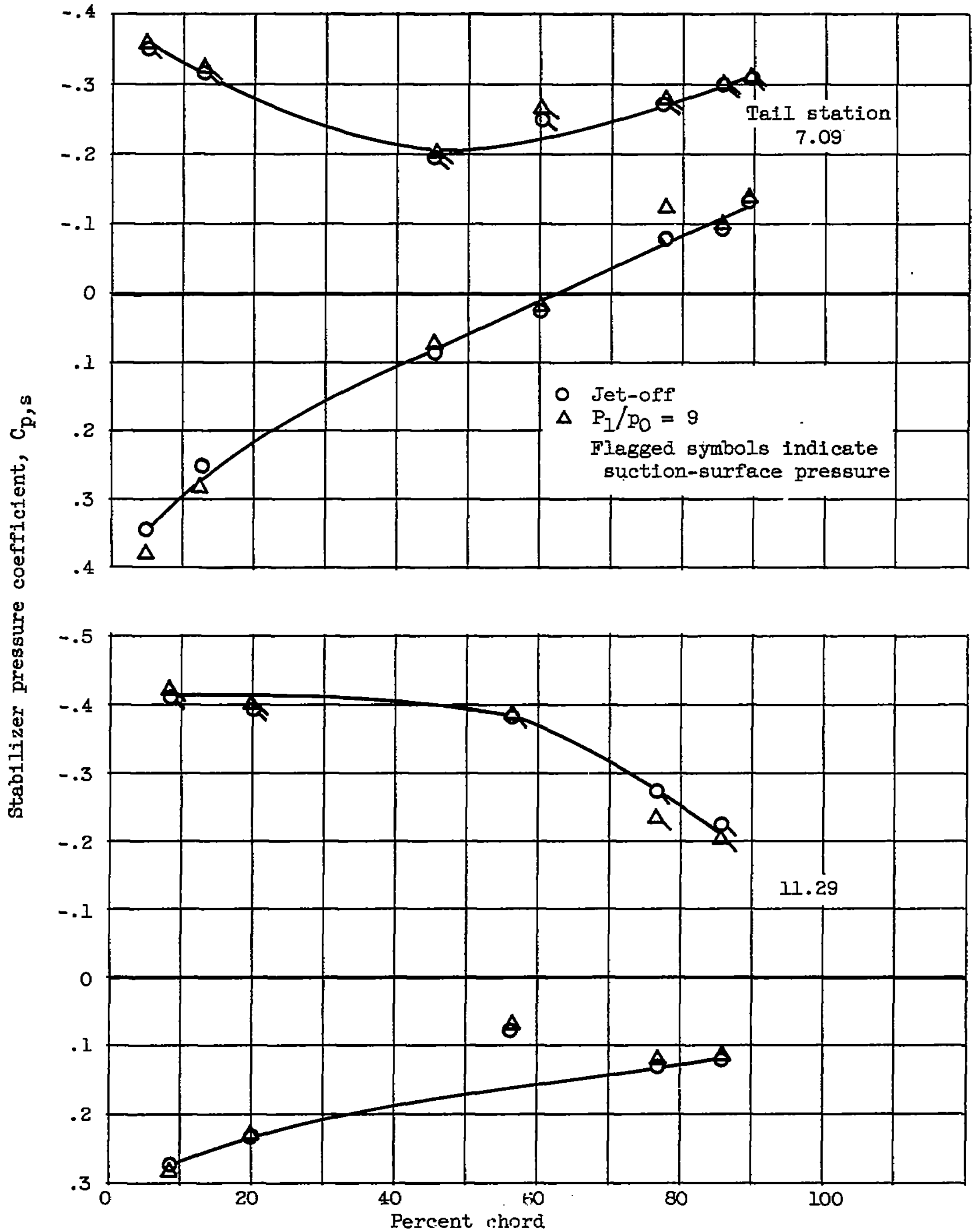

(d) Concluded. Stabilizer in fore position. Deflection angle, 10°.

Figure 6. - Concluded. Effect of jet pressure ratio on pressure distribution of stabilizer at free-stream Mach number of 1.5.

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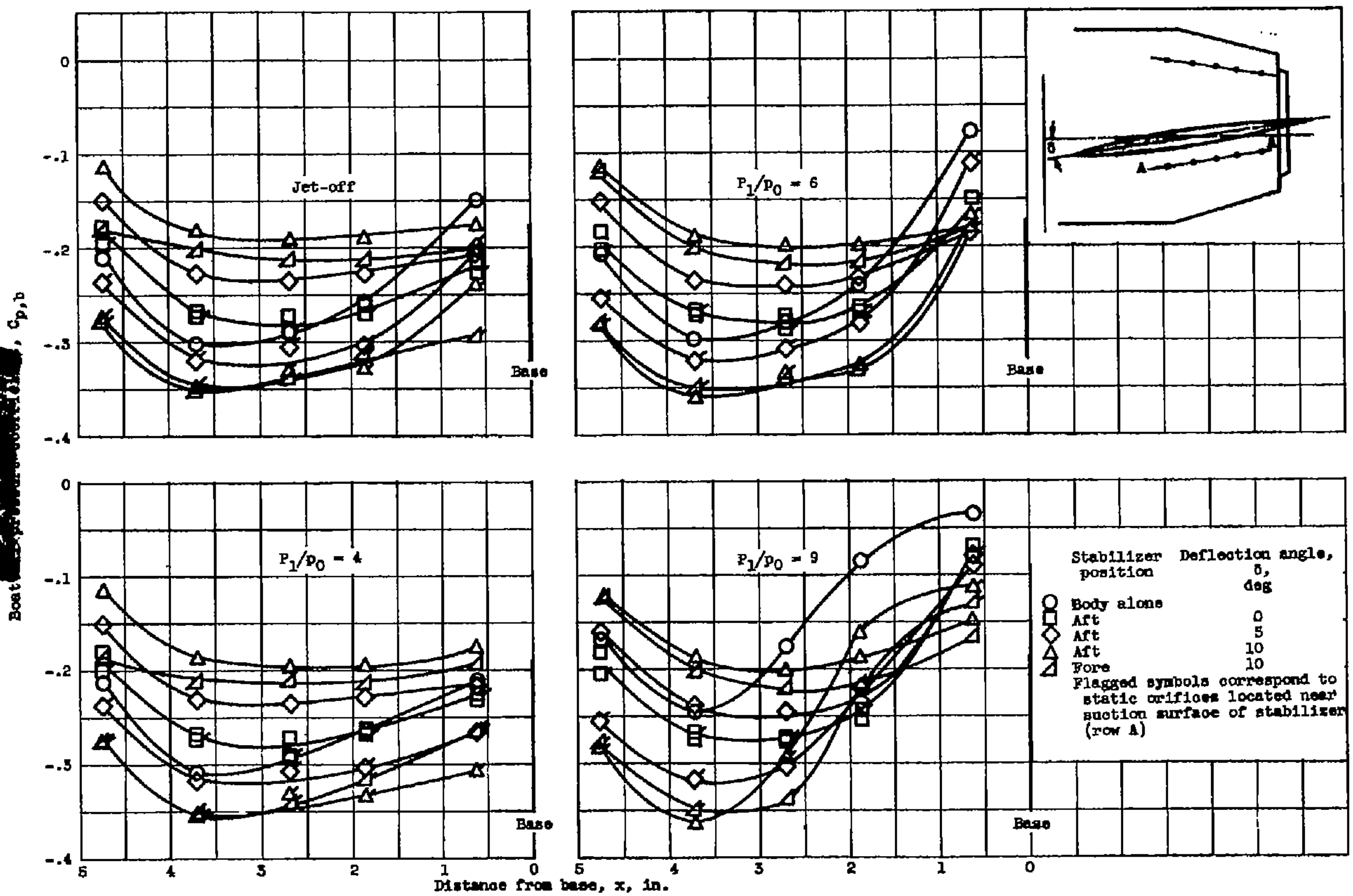

Figure 7. - Effect of stabilizers on boattail pressure coefficient at free-stream Mach number of 1.5.

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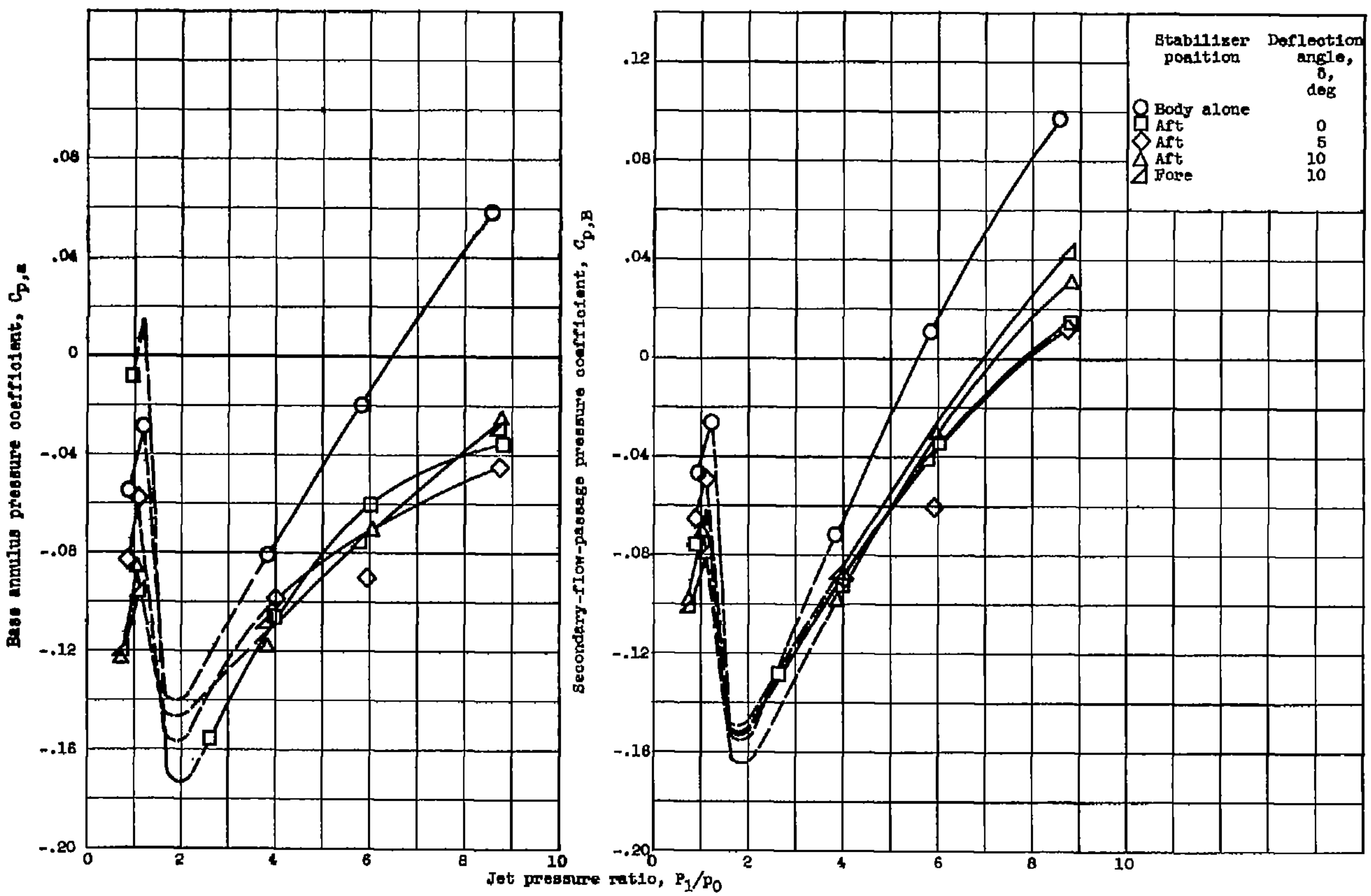

Figure 8. - Effect of stabilizer on base annulus and secondary-flow-passage pressure coefficients at free-stream Mach number of 1.5.